FINAL
TRAINING AREAS WORKPLAN

FOR THE
CAMP EDWARDS IMPACT AREA
GROUNDWATER QUALITY STUDY

MASSACHUSETTS MILITARY RESERVATION
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Prepared for

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1.0 Introduction

This workplan has been prepared for supplemental investigation activities under Phase IIa of the Impact Area Groundwater Study (IAGS) at the Massachusetts Military Reservation (MMR). The Environmental Protection Agency's (EPA's) Modified Scope of Work (SOW) dated July 17, 1998 identifies specific training areas, ranges, and other areas to be investigated (Table 1-1). This workplan has been developed to address the nature and extent of contamination associated with past training activities conducted in the MMR Training Areas. The plan focuses on, but is not limited to, activities involving the use of chemical warfare simulants (riot control agents), pyrotechnic smoke devices (smokes), and herbicide use at ten of the training areas mandated in the SOW.

The conditions under which these items were used at MMR have been developed from a compilation of findings documented in the Draft Range Use History Report (Ogden, 1997), Ordnance and Explosives Archives Search Report (USACE, 1999) and its Addendum, and the draft Completion of Work Report (CWR) for the Camp Edwards Impact Area Groundwater Quality Study (Ogden, 1998a). The USACE (1999) reports provide training area use information that supplement the Ogden (1997) report findings, and represents the most comprehensive summary to date of historical training area use at MMR. Both the Ogden (1997) and USACE (1999) reports contain numerous interviews with persons knowledgeable of MMR range use history. Information gathered during these interviews was used to better understand documented historical use of each training area, and to assist in developing investigation strategies. An approach to developing investigations for these areas is presented in the EPA-approved Phase IIa Workplan (Ogden, 1998c and Ogden, 1999). Sampling locations proposed in the subsequent Field Sampling Plan (FSP) will be selected following field reconnaissance measures conducted with EPA and MADEP. These selected locations will be representative of the full range of potential releases associated with training activities to account for ancillary contaminant sources such as chlorinated solvent releases, petroleum spills, and the discovery of chemical agent identification sets (CAIS). A background area, void of both physical and documented evidence of chemical warfare simulant and pyrotechnic smoke use, will be identified during this field reconnaissance survey with the agencies and included in the FSP.

In general, range use histories revealed that training area activities occurred as early as the late 1930s and continued into the 1990s. For several training areas, however, no specific interview reference or documented activity was discovered for dates after 1984. Though no MMR training area will be excluded from this workplan based on the time period in which it was used, in these special pre-1984 cases, investigations would be considered under IRP.

The workplan is comprised of four sections: this Section 1 Introduction, which describes objectives, information sources, and organization; Section 2 Use History Summaries, which summarizes the information available for each specific activity or location; Section 3 Release Potential and Proposed Investigations, which describes the potential environmental impacts associated with a training area activity, and the investigation proposed to evaluate these impacts; and Section 4 References. The attached appendix contains the memorandum of resolution documenting final changes to the draft version of this document.

Information summaries in Section 2 make use of aerial photographs to support much of the documented histories. Digital versions of these photos were used in a Geographic Information System (GIS) that also contains locations of roads, monitoring wells, and other site features, to produce the figures in this workplan. The aerial photos available for this workplan were from 1943, 1955, 1966, 1977, 1986, 1991, and 1994. The dates of each photograph used in this work plan are included in the figure legend. In many cases, with the older photographs, the existing site features (e.g. roads) shown as a color overlay are offset slightly from the historic features indicated on the photograph. This inconsistency results from photo registration error and possibly distortion. In most cases, the shift is minor and the photo still provides useful reference information.

2.0 Use History Summaries

The following discussion of training area use histories is presented under headings that generally follow those presented in the July 1998 EPA SOW. The workplan is divided into separate discussions of chemical warfare simulant use, pyrotechnic smoke use, herbicide use, and other training area activities. Each summary presents a compilation of information gathered from archived documents (historical documents and maps), discoveries made during site inspections conducted by the USACE, and formal interviews.

The following training area histories focus specifically on troop training methods and activities, documented and suspected ordnance use, and actual ordnance observed during site inspections in order to evaluate contaminant release potential at each location. Table 2-1 summarizes for each area and activity in this Phase IIa Supplemental Workplan, the type of suspected ordnance or chemical use, and likelihood of the presence of ordnance or chemical release based on the historical information gathered. Table 2-1 also summarizes proposed investigations for each area, which are discussed in Section 3.

Training areas generally consist of large, open areas used for troop training exercises. The relative locations of training areas referenced in the July 1998 EPA SOW are shown in Figure 2-1.

2.1 Chemical Warfare Simulant Use

In the July 1998 SOW under Section 3 Phase IIa Activities, chemical warfare training is identified as an activity of concern. Based on archival information, the compound CS (2-chlorobenzalmalononitrile), a chemical irritant typically used in as a non-lethal riot control agent (tear gas), was used in gaseous form produced from either pellets or grenades during training exercises to simulate chemical warfare conditions. The typical tear gas grenade consists of CS, a burning mixture consisting of black powder (potassium nitrate, sulfur, and charcoal), and an ignition mixture of iron oxide, zirconium, and titanium.

The SOW specifies that a representative training area where chemical warfare training was historically performed be selected for investigation (3.d.i). It further identifies, under Section 4 Phase IIb Activities, specific training areas to be investigated. These areas include:

4.a.ii B-8 (in the area south of Donnely Pond near the benchmark)
4.a.iii A-5
4.a.vi Land Nav II
4.a.x CBR site (on 1949 range map)
4.a.xii A-6 (near gun position 24)

Other areas suspected of similar training, including Wheelock Road across from Range Control, Pew Road north of the intersection with Estey Road and Training Area C-16, were identified in personal interviews and from actual ordnance discoveries.

Though a 1941 memorandum indicates that Camp Edwards was evaluated for the adequacy of chemical weapons training, no record of any chemical warfare material use at MMR has been discovered. Tear gas is not a chemical warfare agent, but is used as a breathing and eye irritant to provide soldiers with a training situation that simulates chemical warfare conditions. Tear gas is used routinely by police departments as a non-lethal riot control agent. Any visible evidence of chemical agent release discovered during field reconnaissance measures will be considered in subsequent sampling plans.

2.1.1 Identification of Possible Use Areas

Most interviewees indicated that ordnance use during troop training exercises in the training areas consisted of flares, star clusters, parachute flares, trip flares, M80s, grenade and artillery simulators, and smoke grenades (USACE, 1999b, USACE, 1999c, and USACE, 1999d). Tear gas grenades were rarely referred to by the interviewees, however, as discussed above, open-air chemical warfare simulant training may have occurred on occasion at Camp Edwards. One interviewee alleged that tear gas training was conducted

at the following locations: Training Areas A-5, A-6 near Gun Position 24 (GP-24), B-8, Wheelock Road across from Range Control, and Land Nav II (Ogden, 1997a). Another interviewee provided details of tear gas pellet use inside enclosed buildings at the NBC (Nuclear, Biological, and Chemical) Training Area (USACE, 1999a). The current MMR range use map (from 1994) depicts an NBC training area on the north side of Estey Road between Pew and Frank Perkins Road in Training Area A-4. The same interviewee (USACE, 1999a) indicated tear gas grenades were only rarely used within the Training Areas C-15, BA-4, and A-4 (USACE, 1999a). During a field inspection conducted for the Archive Search Report (USACE, 1999), a single tear gas grenade was found in Training Area C-16. Reports of ordnance discoveries at MMR were summarized by USACE for the period of 1980 to 1998 (USACE, 1999). Tear gas grenades were identified at several locations, including one in Training Area C-16 and one at GP-12.

2.1.2 Description of Possible Use Areas

Unimproved roads on a 1949 range use map (USACE, 1999) are the earliest indication of activity within the training areas referenced in this workplan. The following summaries provide general descriptions of each training area including locations, sizes, access roads, and available information on training activities performed at each.

Training Area B-8 is comprised of approximately 411 acres located west of the Impact Area (Figure 2-2) and bounded on the north by Wood Road, south by Monument Beach Road, east by Burgoyne Road, and west by the MMR property boundary. Significant geographic features within Area B-8 include Donnely and Little Halfway Ponds. A 1970s era range layout map, which designates this Area B-8 as Range 7 (USACE, 1999), shows Mortar Position 2 (MP 2) and Old Range B (a former rifle and machinegun range) located in the southernmost limits of Area B-8.

No specific information on the historical use of tear gas in training exercises conducted in Area B-8 has been discovered to date.

Training Area A-5 is comprised of 316 acres located southwest of the Impact Area (Figure 2-3) and is bounded by Wheelock Road on the north, Pocasset-Forestdale Road on the south, the MMR property boundary to the west, and Pew Road to the east (DMA, July 1986). A 1949 map depicts a rifle range known as Combat Training Range #1 centrally located on the south side of Area A-5 along Fredrikson Road (USACE, 1999). The 1970s era range layout map designates this training range as Range 5 (USACE, 1999). There is no available information linking Combat Training Area #1 (Range 5) with training involving tear gas.

Land Nav II is shown as a subdivision of Area A-5 on the current range map (DMA, August 1994), and comprises approximately 112 acres of the eastern side of Area A-5

east of Fredrickson Road (Figure 2-4). No specific information related to tear gas use in training exercises was discovered for Land Nav II, however, the references to tear gas training along Pew Road mentioned above, which borders Land Nav II, may be associated with training exercises conducted there.

Training Area A-4 is a 196-acre area southwest of the Impact Area bounded on the south by Estey Road, north by Pocasset-Forestdale Road, west by Pew Road, and east by Frank Perkins Road (Figure 2-5). The CBR (or chemical, biological, radiological) Training Area shown on the 1949 range map was located within Training Area A-4. The area formerly designated as CBR is currently designated as the NBC (or nuclear, biological, chemical) Training Area and includes Quonset hut buildings on Estey Road. According to one interview statement, training activities included use of tear gas inside enclosed buildings at the CBR/NBC Training Area (Ogden, 1997d and USACE, 1999a), and in field training near the Ammunition Supply Point (ASP) (Ogden, 1997a). The ASP is located at the intersection of Pew and Pocasset-Forestdale Roads in the northwest corner of Training Area A-4.

Training Area A-6 comprises 327 acres southwest of the Impact Area and immediately north of Training Range A-5 (Figure 2-6). It is bounded by Wheelock Road on the south, Frank Perkins Road on the north and east, and the MMR property boundary to the west. A 1970s-era range layout map identifies this area Range 6 (USACE, 1999). Other than a reference to tear gas use near GP-24 located in the southeastern corner along Wheelock Road (Ogden, 1997a), no specific information regarding this form of training activity has been discovered to date for this training area.

Training exercises involving tear gas on Wheelock Road across from the Range Control facility (Figure 2-7) were referred to in one interview (Ogden, 1997a). It is not clear from the interview reference or from aerial photographs specifically where these activities took place. Possible locations include cleared areas on the south side of Wheelock Road near Pine Hill in what is now the northern limits of Training Area A-5 (including Land Nav II) and Training Area BA-4, and north of Wheelock Road at the former Anti Aircraft Miniature Range adjacent to Pine Hill (Figure 2-7). No other historical information regarding this form of training in this area has been identified.

Training Area C-16 is located northeast of the Impact Area, bounded by Route 6 on the north, Route 130 on the east, Gibbs Road on the south, and Barlow Road on the west (Figure 2-8). With the exception of a tear gas grenade discovery (USACE, 1999), no other information regarding the use of tear gas has been discovered for Training Area C-16.

2.2 Smoke Use

EPA's July 1998 SOW identifies, under Section 3 Phase IIa Activities, pyrotechnics use as an activity of concern (3.d.iii) and specifies that a representative training area where these devices were historically used be selected for investigation. The SOW further identifies under Section 4 Phase IIb Activities, specific training areas to be investigated where smokes are known or suspected of having been used. They include:

4.a.i C-13, C-14, C-15
4.a.iii A-5
4.a.iv A-4
4.a.vi Land Nav II
4.a.vii Pine Hill

The chemical constituents that comprise the various types of pyrotechnic smoke grenades typically include fuel (usually powdered sugar), an oxidizing compound (usually potassium chlorate), diatomaceous earth as a binder, a coolant (usually magnesium carbonate), and various colored dyes. Some of the chemical constituents of the dyes used in these smokes prior to the early 1980s are considered toxic. Green, purple and yellow smoke grenades were allegedly used in troop training exercises along with other devices including, but not limited to, flares, star clusters, parachute flares, trip flares, M80s, and grenade and artillery simulators during training exercises (USACE, 1999a, USACE, 1999b, USACE, 1999c, and USACE, 1999d).

Smoke was also produced through the vaporization of various petroleum fuels.

2.2.1 Identification of Possible Use Areas

Several interviewees referenced the historic use of pyrotechnic smokes in the open areas of Training Areas A-4, A-5, C-13, C-14, C-15, Land Nav II, and Pine Hill. They did not, however, provide specific information on the quantities or locations of smoke grenades used within each identified area. Reports of ordnance discoveries at MMR were summarized by USACE for the period of 1980 to 1998 (USACE, 1999). Smokes and pyrotechnics were identified at several locations, including the following:

- E Range (1 star cluster)
- Old J-2 Range (smoke grenades)
- L Range (2 smoke grenades)
- IBC Range (2 artillery simulators, 4 smoke grenades)
- U Range (1 artillery simulator)
- Training Area A-1 (1 grenade simulator)

- Training Area A-2 (1 parachute flare, 1 artillery simulator)
- Training Area B-7 (1 artillery simulator)
- Training Area B-8 (2 artillery simulators, 2 grenade simulators)
- Training Area B-9 (1 parachute flare)
- Training Area B-12 (1 artillery simulator)
- Training Area BA-1 (smoke rifle grenades)
- Training Area BA-3 (1 trip flare, 1 artillery simulator, 1 flare)
- Training Area BA-4 (1 smoke grenade, 1 artillery simulator)
- Training Area C-16 (1 artillery simulator, 1 grenade simulator, 1 tear gas grenade, 1 smoke grenade)
- GP-2 (1 smoke grenade)
- GP-6 (1 artillery simulator)
- GP-9 (1 artillery simulator)
- GP-22 (1 grenade simulator)
- GP-24 (1 artillery simulator)
- 3600 Area (2 smoke grenades)
- Burgoyne Road (1 smoke grenade)
- Wheelock Road (5 artillery simulators, 1 grenade simulator)
- Wood Road (1 grenade simulator)
- Unknown (5 artillery simulators)

Considering the ordnance discovery information listed above, it appears that smokes and pyrotechnics were used throughout the training ranges. Following is a description of the training areas that were identified in the July 1998 SOW. The other training areas listed above have similar sizes and features.

2.2.2 Description of Possible Use Areas

Training Area C-13 is comprised of 578 acres and is located north of the Impact Area (Figure 2-9). It is bounded on the north by Route 6, south by Gibbs Road, west by Cat Road, and east by North Avery Road. Significant features of this training area include the PAVE PAWS radar station located midway along the western border of Area C-13. Gun Position GP-22 is also located within the limits of the training area on Monument Swamp Road. No specific information regarding pyrotechnic smoke use within the limits of Area C-13 has been discovered.

The 524-acre Training Area C-14 is bounded by Route 6 on the north, by Gibbs Road to the south, by North Avery Road to the west and by Spruce Swamp Road to the east (Figure 2-10). Significant geographic features within Training Area C-14 include the former E-3 Range (now known as Demo Area 2), Gibbs Pond, Spruce Swamp, and Fuel Spill FS-14. With the exception of several cleared areas possibly used for troop training

along Goat Pasture Road, no other evidence or information on pyrotechnic smoke use within Training Area C-14 has been identified.

Training Area C-15 is comprised of 587 acres and is bounded on the north by Route 6, Gibbs Road to the south, Spruce Swamp Road to the west, and Barlow Road to the east (Figure 2-11). The only significant geographic feature identified in aerial photographs is Raccoon Swamp located in the northwest portion of the training area. With the exceptions of cleared areas possibly used for troop training adjacent to MW-52 and along a northeast-southwest trending road bisecting the training area, no other evidence or information on smoke use in Training Area C-15 has been identified.

Physical descriptions of Area A-4 (Figure 2-5), Land Nav II (Figure 2-4), and Area A-5 (Figure 2-3) are provided under Section 2.1.1. Pine Hill is located in the southernmost portion of Training Area B-7 near the Range Control facility (Figure 2-7), and is the former location of the Anti Aircraft Miniature Range (Old D Range). No specific information on the historic use of smokes in these four areas has been discovered to date.

2.3 Herbicide Use (B-12)

The July 1998 EPA SOW identifies Training Area B-12 in section 3.d.ii as an area where field experiments on herbicides were reportedly conducted, and specifies that an assessment of the nature and extent of contamination be conducted there. Training Area B-12 consists of approximately 749 acres in the region northwest of the Impact (Figure 2-12) and is bounded by Cat Road on the east, Gibbs Road on the south, and the MMR property boundary to the north and west. Significant geographic features located within Area B-12 include Gun Positions GP-17 and GP-18, and three utility line corridors that emerge from a major substation located on the western side of the training area.

In a report documenting the findings of an experimental application of the herbicides Garlon 3A and Tordon 101 (Deubert, 1985), tests were performed on the western side of Training Area B-12, presumably along the electrical transmission line right-of-way. The exact testing location, however, was not specified in the report. The study was performed to determine the release potential of herbicides to soil and groundwater after application to vegetation.

2.4 Other Training Area Activities

Other training area activities were identified in the ASR that involved the use of training devices and materials containing explosive and propellant compounds. Many of these activities are referenced in the ASR Table 4-4 entitled *Summary of MMR Range Use History* and the ASR Table 4-5 entitled *Summary of OE Discoveries 1980-1998*. Other training area activities involving chlorinated solvents use and incidents resulting in

petroleum product spills in the training areas have also been referred to in supplemental interviews reported in the ASR Addendum.

3.0 Release Potential and Proposed Investigations

The following sections provide an assessment of contaminant release potential resulting from the historical and recent use of each of the training areas presented in Section 2. Each subsection below provides a summary of known or suspected ordnance used and assesses potential impacts to soil and groundwater. For those sites where a reasonable potential impact exists, an investigation is proposed to evaluate the nature and extent of the associated contaminants. Training areas are presented in the same order presented in Section 2 above.

3.1 Chemical Warfare Simulant Use

The historical information on tear gas use revealed that it was used as a chemical warfare agent simulant for troop training purposes at MMR. The training was reportedly performed both in enclosed buildings and in open training areas. In order to evaluate the impacts of this form of training at MMR, an investigation of the nature and extent of potential tear gas residue is needed. Investigation of the nature and extent of tear gas residue requires selection of appropriate analytical methods for the measurement of CS. Because CS is readily susceptible to environmental degradation, the CS breakdown product chlorobenzaldehyde has been selected as a suitable representative compound.

3.1.1 Release Potential

Tear gas grenades are specifically designed to disperse irritant gas into the air. When used in outdoor training exercises, as would be the case in the training areas, residues of the tear gas constituents, if present, are likely to be distributed in soil as a function of air movement. Tear Gas training within the Quonset huts at the NBC training area, where it was repeatedly used, presents a different release potential. Under the unique conditions within the structures, where photodegradation and soil infiltration are minimized, the dirt floor of these structures is likely to have the highest concentrations of residual tear gas constituents resulting from this type of training exercise.

3.1.2 Investigation Objectives

The Guard proposes to conduct an investigation of soil conditions within the Quonset huts to characterize tear gas residual under what is presumed to be worst-case conditions, where gas was confined within a structure. In order to conduct this investigation, the Guard proposes to begin development of an analytical method for detecting

chlorobenzaldehyde in soil and groundwater. A summary of the analytical method considered feasible for this analyte will be provided to the agencies as method development is completed. With EPA and MADEP approval, the method will be included in the IAGS Quality Assurance/Quality Control (QA/QC) Plan. Method detection limits and sample management requirements (sample collection and handling) will be documented in the QA/QC Plan.

The Guard proposes to collect representative soil samples from grid locations within the Quonset huts and other training areas to quantify residual concentrations.

3.1.3 Investigation Scope

The Guard will perform soil and groundwater investigations at representative areas where CS training was known or suspected to have been used. No specific high-use areas, other than indoor use at the NBC Quonset Huts, have been positively identified to date. The USACE summary of ordnance discoveries and interviews indicate that CS may have been used historically in Training Areas B-8, A-5, Land Nav II, C-15, BA-4, A-4, and GP-12. The Guard will continue records research on historical tear gas training activities, including reviewing the ASR and its Addendum, in an effort to identify supplemental information on past CS use.

The Guard proposes to conduct an investigation of chlorobenzaldehyde residuals inside the Quonset huts. A composite soil sample will be collected from the floor of each Quonset hut. Grid dimensions and sampling intervals will be consistent with Phase IIa sampling to the extent practical given the potential restrictions imposed by the interior layout of the Quonset huts. In the event that site conditions suggest alternative grid dimensions are appropriate, the Guard, in consultation with EPA, will consider alternate configurations. Soil samples will be analyzed for chlorobenzaldehyde using the approved analytical procedure.

In addition, the Guard will perform reconnaissance surveys with EPA and MADEP in the six training areas and single gun position identified above for evidence of past CS use. Reconnaissance efforts will include possible former training locations along Pew Road in an effort to locate the former 1940s chemical warfare training simulation facilities. A suitable number of soil sampling grids will be established by the Guard with input from EPA and MADEP in those areas were evidence of potential releases or chemical agent disposal is discovered. Soil samples will be analyzed for chlorobenzaldehyde, plus the full suite of Phase I analytes. Background sampling locations for tear gas will also be established based on the reconnaissance.

Proposed sampling locations based on the reconnaissance and records research will be documented in a subsequent FSP for agency and stakeholder review.

3.2 Smoke Use

Historical information summarized in Section 2 indicates that pyrotechnic smokes were used as part of troop training exercises in many of the open training areas. In order to evaluate the environmental impacts of smoke use, an investigation of the nature and extent of residual compounds, particularly the dye components of these devices, resulting from past use is needed.

Investigation of the nature and extent of smoke residue requires development of appropriate analytical methods for measurement of dyes. Currently there is no approved method for quantifying dyes in soil.

The Draft PEP Analytical Report (Ogden, 1998b) presents information on a subset of compounds believed to be present in smoke devices. Since the preparation of the PEP Report, additional information has been gathered on typical compounds present in various smokes, as well as the fate-and-transport properties of some of these compounds. This information is summarized below.

3.2.1 Smoke Compositions

The M18 green smoke grenade components include 325 grams of a dye mixture made up of 12.5% Dye Solvent Yellow 33, 29.5% Dye Solvent Green 3, 17% magnesium carbonate, 24.5% potassium chlorate, and 16.5% powdered sugar (Davidson and Hovatter, 1987a). Rubin and Buchanan, (1983) indicate green smoke is formulated to contain 1,4-di-p-toluidino-9,10-anthraquinone (PTA), BZA, and dibenzochrysenedione (DBC) in a ratio of 70:20:10. Analysis of green smoke indicated PTA and DBC as well as Marcol (2.9%), a long chain hydrocarbon used as an antidusting agent. DBC was identified with the remainder of insoluble unidentified compounds (Rubin and Buchanan, 1983). Dye Solvent Green 3 is FDA approved for use in contact lenses, cosmetics and external drugs. Decomposition products from the combustion of the grenade and oxidation include 1-p-toluidinoanthraquinone, 1-p-toluidino-4-aminoanthraquinone, p-toluidine, 1-aminoanthraquinone, and 1-p-toluidinoanthrone (Davidson and Hovatter, 1987a). Dye Solvent Green 3 is photodegradable, hydrophobic, and will remain in a particulate form.

The M18 yellow smoke grenade components include 325 grams of dye mixture made up of 42% Dye Solvent Yellow 33, 21% magnesium carbonate, 22% potassium chlorate, and 15% powdered sugar (Davidson and Hovatter, 1987b). Rubin and Buchanan, (1983) indicated yellow smoke is formulated to contain BZA and DBC in a ratio of 64:36). Analysis of yellow smoke indicated BZA (45%) and DBC (27.2%) as well as Marcol (2.9%). Impurities of less than 1% include anthraquinone and an unidentified compound

likely a diketone with a molecular weight of 366. The remainder of the smoke constituted unidentified compounds (Rubin and Buchanan, 1983). Dye Solvent Yellow 33 is made up of 98% 2-(2-quinolyl)-1,3-inandione [CAS No. 83-08-9], 1% 3-hydroxy-2-(2-quinolinyl)-1H-inden-1-one [CAS No. 5662-02-2], and 1% 2-(2(1H)-quinolylidene)-1H-indene-1,3-(2H)-dione [CAS No. 5662-03-3]. Dye Solvent Yellow 33 has a very low toxicity and is approved by the FDA for use in cosmetics (Davidson and Hovatter, 1987b). The primary physical form is a particulate.

Red smoke is formulated to contain MAA (Rubin and Buchanan, 1983). Analysis of red smoke indicated the following makeup based on the analytical techniques used. The Thin Layer Chromatography method indicated MAA with 5 impurities and Gas Chromatography indicated 25 impurities at trace levels. The largest impurity is anthraquinone (25-30% of the MAA) (Rubin and Buchanan, 1983). Other compounds present at less then one percent are aminoanthraquinone (DAA), azobenzene, azoxybenzene, aminobiphenyl, phenlydiazobenzene and either dibenzoacenapthylene, or phenylanthracene. There were also trace amounts of unidentified impurities. An insoluble reside that composes approximately 8% of the formulation appears to be chloroform (Rubin and Buchanan, 1983).

The M18 violet smoke grenade components include 325 grams of a dye mixture (42%) made up of (80% violet, 1,4-diamino-2,3-dihydroanthraquinone (DDA) and 20% Dye Disperse Red 9), 24% sodium bicarbonate, 25% potassium chlorate, and 9% sulfur. Minor dye components (<1%) include anthraquinone, DDA, aminonapthalene, aminoanthraquinone, phenlydiazobenzene, 4-diaminoanthraquinone (DAA), and carbon residues (Davidson et al. 1988 and Rubin and Buchanan, 1983). An insoluble residue, representing 24% of the starting compound, could not be identified (Rubin and Buchanan, 1983). DDA readily and completely oxidizes to DAA.

The Cichowicz and Wentsel (1983) report indicated the toxic dyes were proposed to be replaced with non-toxic dyes in the early 1980s. Actual phase out dates of particular dyes was unavailable. Dye Disperse Red 9 (1-methylaminoanthraquinone) was proposed to be replaced with Sudan R (o-methoxy-phenyl-azo-B-napthol). The Violet Dye (1,4-diamono-2,3-dihydroanthraquinone) was proposed to be replaced with Solvent Violet 36. Dye Vat Yellow 4 (dibenzo (b, def) chrysene-7-14-dione) was proposed to be replaced with Solvent Yellow 33 Dye (2-(2-quindolyl)-1,3-indandione). The benzanthrone Green Dye (7-H-benz (de) anthracene-7-one) was proposed to be replaced with Solvent Green 3 (1,4-di-p-toluidinoanthraquinone).

Red Phosphorus consists of 95 % red phosphorus and 5% butyl rubber with approximately 1% of this mixture containing mineral oil and 1% talc in a felt base (Voris et al. 1987). Red Phosphorus is unstable and will slowly and spontaneously change to form phosphine and various oxyacids. White phosphorus is made up of unpolymerized

tetrahedra of phosphorus atoms containing less than 0.02 % impurities of arsenic and trace levels of hydrocarbons. Phosphorus pentoxide is produced from the combustion of phosphorus in contact with air and then immediately hydrates with moisture in air to form phosphorus acids such as orthophosphoric, pyrophosphate, and tripolyphosphate on up to P_{13} polymers (Brazell et al. 1984). The concentrations of organic compounds was stated to be very low, but not quantified.

Vaporizing fuel at high temperature and then passing it through a stream of nitrogen gas produces the diesel and fog oil smoke. The constituents are essentially fuel-related compounds such as BTEX, PAHs, and DRO, i.e. n-$C_{11}H_{24}$ through n-$C_{20}H_{42}$ (Brazell et al. 1984). Fog Oil is composed of a higher distillation fraction than diesel at 30% aromatic hydrocarbons and 70% aliphatic hydrocarbons by weight. All compounds present in neat fuel are present in the Fog Oil and diesel smoke but at lower concentrations.

3.2.2 Release Potential

Smoke grenades are specifically designed to disperse smoke into the air. When used in outdoor training exercises, as would be the case in the training areas, residues of smoke in soil are likely to be dispersed as a function of air movement. Considering the release mechanism, it seems unlikely that significant quantities or concentrations of these compounds ever existed as residuals in soil above a certain concentration. It is possible, however, that if these compounds do persist in soil, there is a potential for release to groundwater. This would be particularly true for those residual compounds that are relatively insoluble and not photodegradable.

3.2.3 Sampling Objectives

To effectively assess soil and groundwater conditions resulting from the use of pyrotechnic smokes, the Guard recommends soil and groundwater investigations at selected, representative training areas where there were heavy smoke use. In order to conduct this investigation, the Guard will begin development of suitable soil and groundwater analytical methods for detecting the following chemical compounds associated with pyrotechnic smoke use:

- benzathrone (yellow dye)
- dibenzo(a,h)pyrene-7,14-dione (vat yellow dye)
- 1-methylaminoanthraquinone (red dispersal dye)
- 1-4-diamino-2,3-dihydranthraquione (violet dye)
- 1-4-bis(p-toluidino)anthraquinone (green dye)

A summary of the analytical method that is considered feasible for these analytes will be provided to the agencies as method development is completed. Two other pyrotechnic

smoke constituents of interest, hexachloroethane (HCE) and barium nitrate, are analytes that can be detected under current IAGS methods.

The methodology selected for the above compounds will be submitted to EPA and MADEP for approval prior to inclusion in the IAGS Quality Assurance/Quality Control (QA/QC) Plan. Method detection limits and sample management requirements (sample collection and handling) will be documented in the QA/QC Plan.

The Guard proposes to collect soil samples from representative training areas where the potential of smoke residues in soil is greatest, and to collect groundwater samples from locations downgradient of these training areas.

3.2.4 Investigation Scope

The Guard will perform soil and groundwater investigations at representative areas where smokes were known to have been used for investigation of potential residuals. No specific high-use areas were identified from the aerial photographs or interview information. The USACE summary of ordnance discoveries indicates that the IBC Range, Training Areas B-8, C-16, A-1 and BA-4 , and the KD Range had somewhat higher frequencies of smoke or pyrotechnic ordnance discovery than the other areas onsite. The Guard proposes to perform an initial investigation of the IBC Range for smoke residuals, considering its smaller size, well-defined limits, and long period of use (since 1980) which should result in higher residuals than the other Training Areas. A field reconnaissance effort will be conducted to better define regions of smokes use within the IBC Range. The Guard proposes to sample soils in and around high-use regions and submit those samples for laboratory analysis of smokes-related compounds.

The Guard will establish up to 10 soil sampling grids within the selected high-use areas at the IBC Range. Grid dimensions and sampling intervals will be consistent with those used in the Phase IIa investigation. In the event site conditions suggest alternative grid dimension are appropriate, the Guard, in consultation with EPA, will consider alternate grid configurations. In addition, the Guard will perform reconnaissance surveys with EPA and MADEP in the four training areas identified above and KD Range for evidence of pyrotechnic smoke use. A suitable number of soil sampling grids will be established by the Guard, with input from EPA and MADEP, in those areas where evidence of potential releases is discovered. Soil samples will be analyzed for the seven smoke constituents identified above, plus the full suite of Phase I analytes. Background sampling locations for smoke constituents will also be established based on the reconnaissance.

Proposed sampling locations based on the reconnaissance and records research will be documented in a subsequent FSP for agency and stakeholder review.

Five monitoring well screens are present in the aquifer downgradient from the IBC Range at MW-17. These wells are already included in the IAGS groundwater monitoring for explosives, volatile organics, semivolatile organics, metals, pesticides, and herbicides. Samples from these wells will also be analyzed for the seven representative smoke compounds described above.

3.3 Herbicide Use (B-12)

The 1985 field experiment on herbicides was conducted to assess the potential release of herbicides to soil and groundwater after application to vegetation. The study concluded the herbicides tested were not persistent enough to leach to groundwater (Deubert, 1985). The most mobile herbicide was Picloram which reached a maximum depth of five feet. The other herbicides tested did not migrate further than 10 inches into soil. After one week of application, the total concentration of herbicide in the 0-5 inch soil sample was less than 500 ug/kg.

The natural degradation of the tested herbicides ranged from less than two weeks up to four to eight weeks. Considering a worse case scenario for the compounds used in this experiment, a soil concentration of 500 ug/kg with an herbicide half life of 8 weeks, concentrations would fall below the EPA Method 8151 reporting limit for herbicides within 56 weeks (approximately one year) from the initial application. Given that the experiment was conducted 14 years ago, it is highly unlikely that herbicide residues associated with the testing continue to exist.

The Guard proposes to collect representative soil samples from two soil grids located along two of the three powerline easements located in the western portion of Training Area B-12 to assess the presence of herbicide residuals. The samples will be analyzed for the full suite of Phase I parameters.

3.4 Other Training Area Activities

The Guard will gather information on the use of explosive or propellant compounds, and training practices involving the use of chlorinated solvents or resulting in the release of petroleum products, during the records search. These other training activities will also be considered during the planned field reconnaissance efforts for evidence of tear gas training and pyrotechnic smoke use in the Training Areas. The Guard will, with input from EPA and MADEP, assess whether the findings suggest potential releases of compounds related to these other activities have occurred. Plans to sample soil from potential source areas will be developed accordingly and presented in a subsequent FSP.

Soil samples collected for assessing the nature and extent of contaminants associated with these other training area activities will be analyzed for the full suite of Phase I parameters. Given the limited information available on the actual locations where these activities may have occurred, the Guard will supplement the soils investigation by including groundwater monitoring results from existing downgradient wells in the assessment. Samples collected from these wells have been analyzed for the full suite of Phase I analytical parameters allowing for the evaluation of groundwater impacts due to releases of explosive and propellant compounds, chlorinated solvents, and petroleum products in the training areas.

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Table 1-1. List of Phase II Locations/Activities in the July 1998 SOW			
Location/Activity	**SOW Phase IIa Reference**	**SOW Phase IIb Reference**	**Workplan Describing Investigations**
Training Areas			
C-13, C-14, and C-15 (smokes)	3.d.iii	4.a.i	Phase IIa
B-8 (tear gas training)	3.d.i	4.a.ii	Phase IIa
A-5 (tear gas and smokes)	3.d.iii, 3.d.i	4.a.iii	Phase IIa
A-4 (smokes)	3.d.iii	4.a.iv	Phase IIa
BA-1 (tunnels/waste disposal)		4.a.v	Phase IIb
Land Nav II (tear gas and smokes)	3.d.i, 3.d.iii	4.a.vi	Phase IIa
Pine Hill or B-7 (smokes)	3.d.iii	4.a.vii	Phase IIa
Engineer Training Site		4.a.viii	Phase IIb
E-3 (demolition area or Engineer Training Site)		4.a.ix	Phase I
CBR	3.d.iii	4.a.x	Phase IIa
Control Areas	3.d.i	4.a.xi	Phase IIa
A-6 (tear gas training)	3.d.i	4.a.xii	Phase IIa
Military Ranges			
L (40mm grenade; M79/203 practice; squad/platoon attack course)		4.b.i.	Phase IIb
G-A/G-B (inactive small caliber)		4.b.ii	Phase IIb
Old H (mortars on Greenway Road)		4.b.iii	Phase IIb
Old A (rockets, grenades. bazookas)		4.b.iv	Phase IIb
IBC (infantry battle course)		4.b.v	Phase IIb
Anti-aircraft		4.b.vi	Phase IIb
GN-1/GN-2 (grenades on Howe and Frank Perkins Road)		4.b.vii	Phase IIb

Table 1-1. List of Phase II Locations/Activities in the July 1998 SOW			
Location/Activity	**SOW Phase IIa Reference**	**SOW Phase IIb Reference**	**Workplan Describing Investigations**
Mock Village		4.b.viii	Phase IIb
Control Areas		4.b.ix	Phase IIb
Anti-Tank Gravity Range A		4.b.x	Phase IIb
Old E (rockets at Frank Perkins and Pocasset Forestdale Road)		4.b.xi	Phase IIb
Old K (high explosive rockets at Wood and Greenway Roads)		4.b.xii	Phase IIb
Other Areas			
Cleared (disturbed areas)		4.c.i	Phase IIb
Ground Scars	3.i	4.c.ii	Phase IIa
Waste Oil Dump Sites (includes suspected sites)		4.c.iii	Phase IIb
Demolition Area 3 (boulder demolition on west side of Impact Area)		4.c.iv	Phase IIb
Demolition Area 4 (truck demolition on south side of Impact Area)		4.c.v	Phase IIb
Other Target Area		4.c.vi	Phase IIb
Air to air Target Darts (TOW missiles)		4.c.vii	Phase IIb
Succonsette Pond (target area for 50 cal MG and 60mm mortars)		4.c.viii	Phase IIa
Baileys Pond (50 cal MG, powder bag, and artillery dumping area)		4.c.ix	Phase I
Donnelly Pond (defoliant drum staging, tear gas training, mortars)		4.c.x	Phase I
Deep Bottom Pond (defoliation accumulation area)		4.c.xi	Phase I
Opening Pond (disposal area)		4.c.xii	Phase I
Gibbs Pond (pesticide spraying)		4.c.xiii	Phase I
Ammunition Supply Points		4.c.xiv	Phase IIb
Small Arms Bermed Ranges	3.j	4.d	Phase IIa

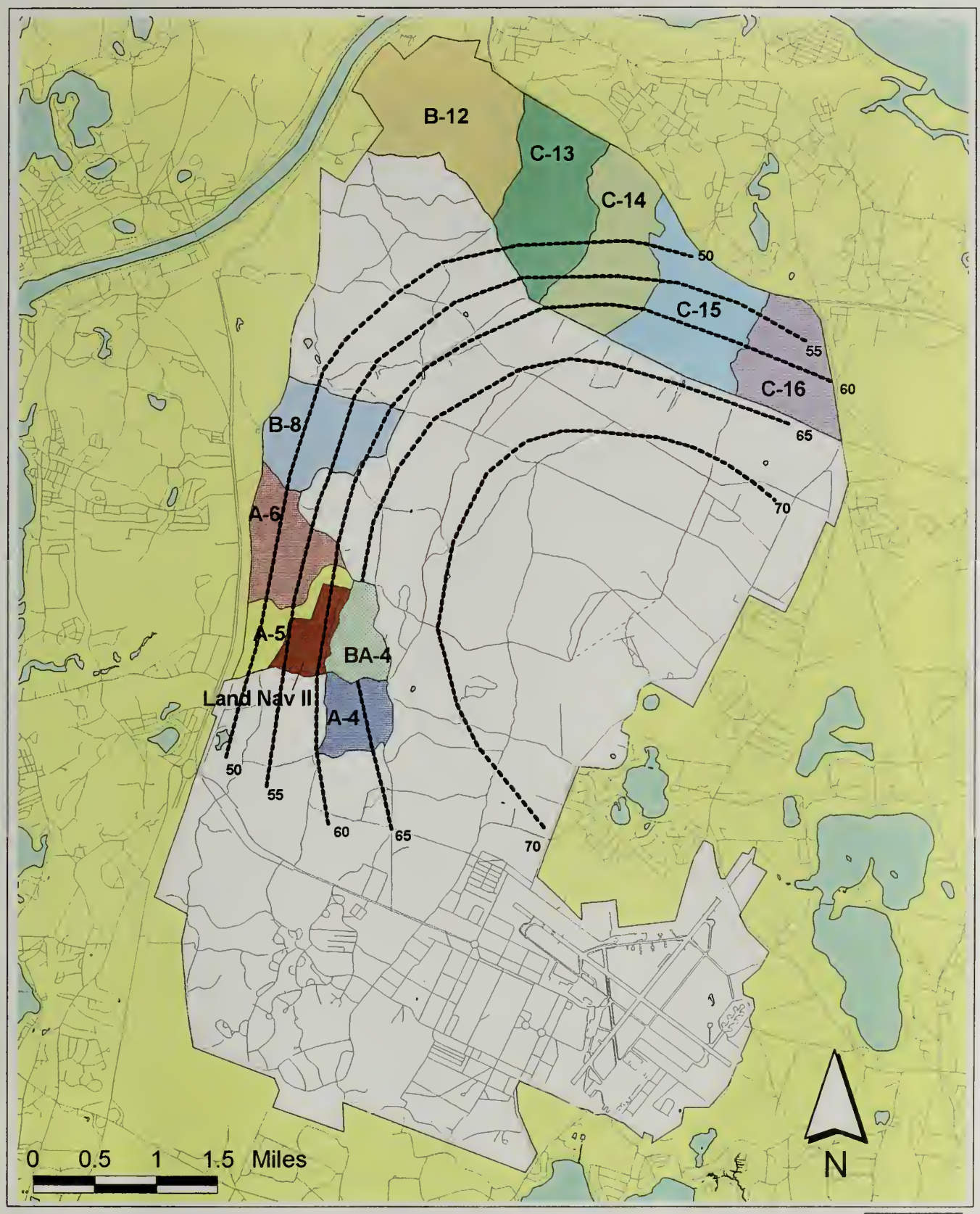
Table 2-1. Training Area Locations and Proposed Investigations

Site Type and Location	Possible Ordnance/Waste Types	Ordnance Potential (C, P, U)[1]	Proposed Investigation Scope
Chemical Warfare Simulation			
Training Area B-8	Tear gas grenades	P	Field Reconnaissance
Training Area A-5	Tear gas grenades near Pew Road/ASP	P	Field Reconnaissance
Land Nav II	Tear gas grenades near Pew Road/ASP	P	Field Reconnaissance
Training Area C-15		P	Field Reconnaissance
Training Area BA-4		P	Field Reconnaissance
Training Area A-4	Tear gas pellets inside buildings at NBC (formerly CBR)	P	Soil investigation
Training Area C-16	Tear gas grenades	C	Field Reconnaissance
GP-12	Tear gas grenade	P	Field Reconnaissance
Pyrotechnic Smokes			
Training Area B-8	Smoke grenades	P	Field Reconnaissance
Training Area C-16	Smoke grenade	P	Field Reconnaissance
Training Area A-1		P	Field Reconnaissance
Training Area BA-4	Smoke grenade	P	Field Reconnaissance
KD Range	Smoke pots	P	Field Reconnaissance
IBC Range	Smoke grenade	P	Soil and groundwater investigation

Table 2-1. Training Area Locations and Proposed Investigations

Site Type and Location	Possible Ordnance/Waste Types	Ordnance Potential (C, P, U)[1]	Proposed Investigation Scope
Herbicide Experiment			
Training Area B-12	Herbicides	U	Soil Investigation
Other Training Area Activities			
Unspecified	Explosives, propellants, chlorinated solvents, petroleum products	P	Field Reconnaissance

Notes:
[1] C – Confirmed, P - Possible, U - Unlikely
ASP = Ammunition Supply Point
NBC = Nuclear, Biological, Chemical Training Site
CBR = Chemical, Biological, Radiological Training Site
IBC = Infantry Battle Course



April 28, 1999

Figure 2-1

Location of Training Areas

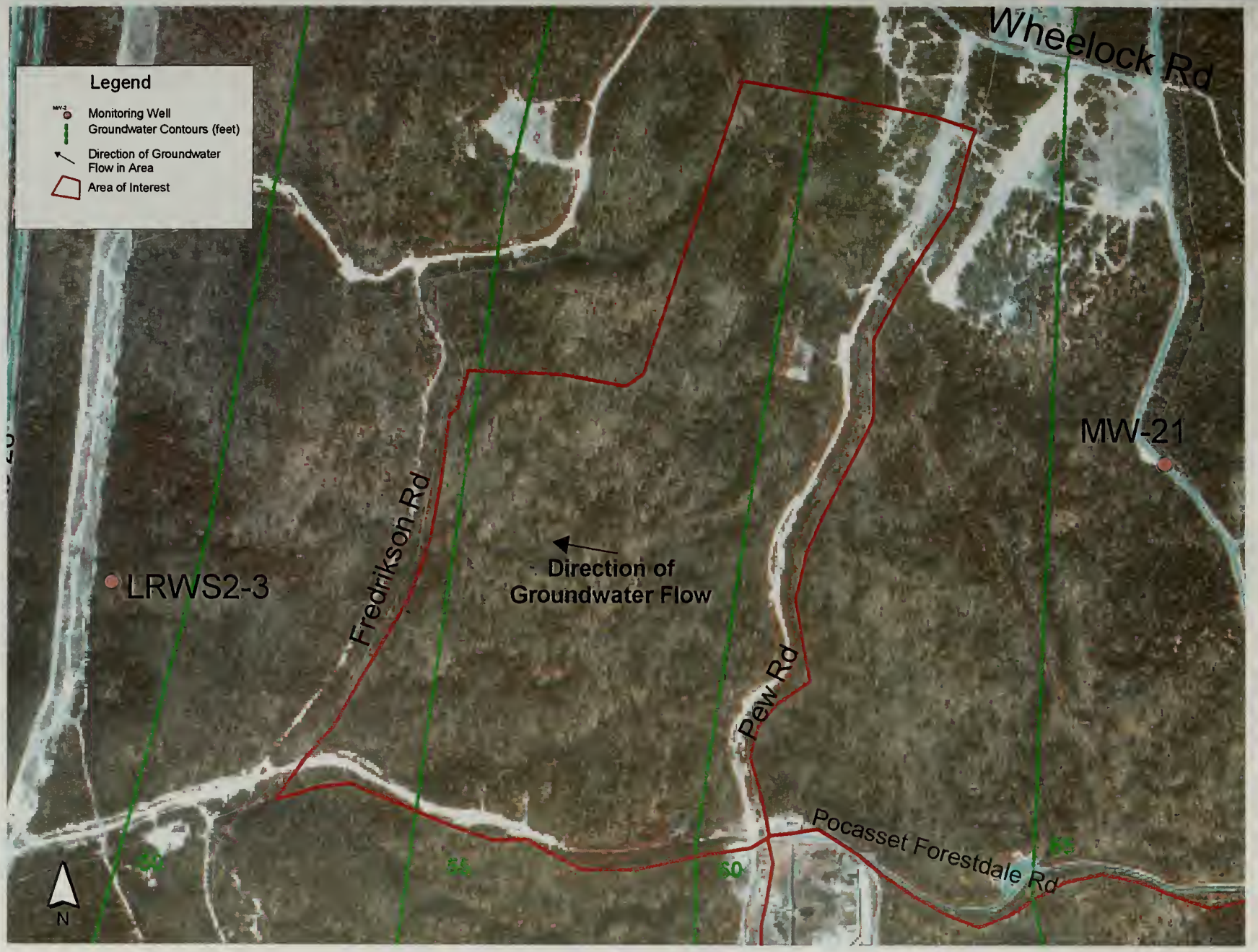
1991 aerial photo as backdrop

Training Area B-8

Figure 2-2

Training Area A-5

Figure 2-3



Training Area
Land Nav II

1991 aerial photo as backdrop

Figure 2-4

Training Area A-4

Figure 2-5

Training Area A-6

Figure 2-6

1991 aerial photo as backdrop

Training Area BA-4

Figure 2-7

0 0.1 0.2 Miles

Training Area C-16

1991 aerial photo as backdrop

Figure 2-8

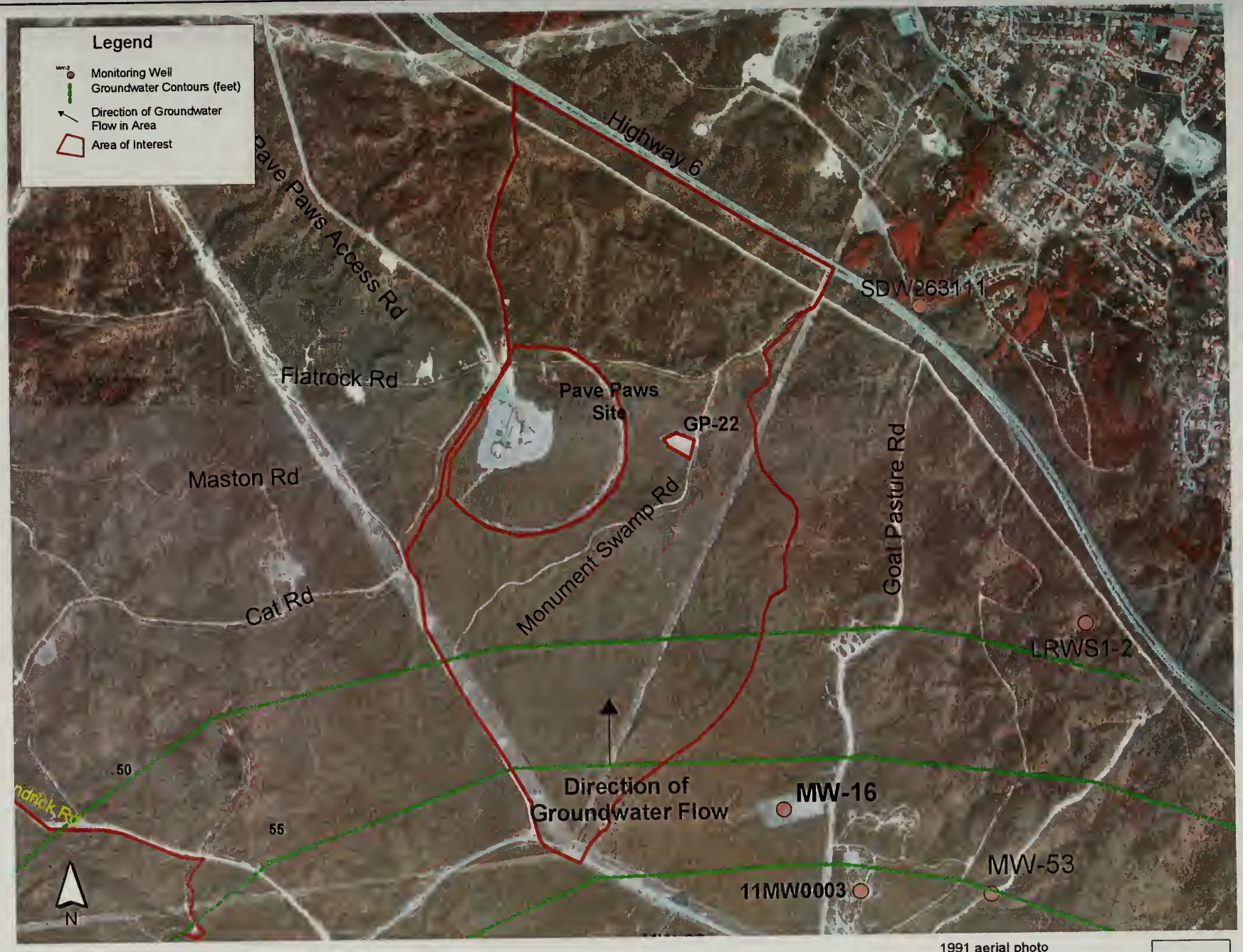
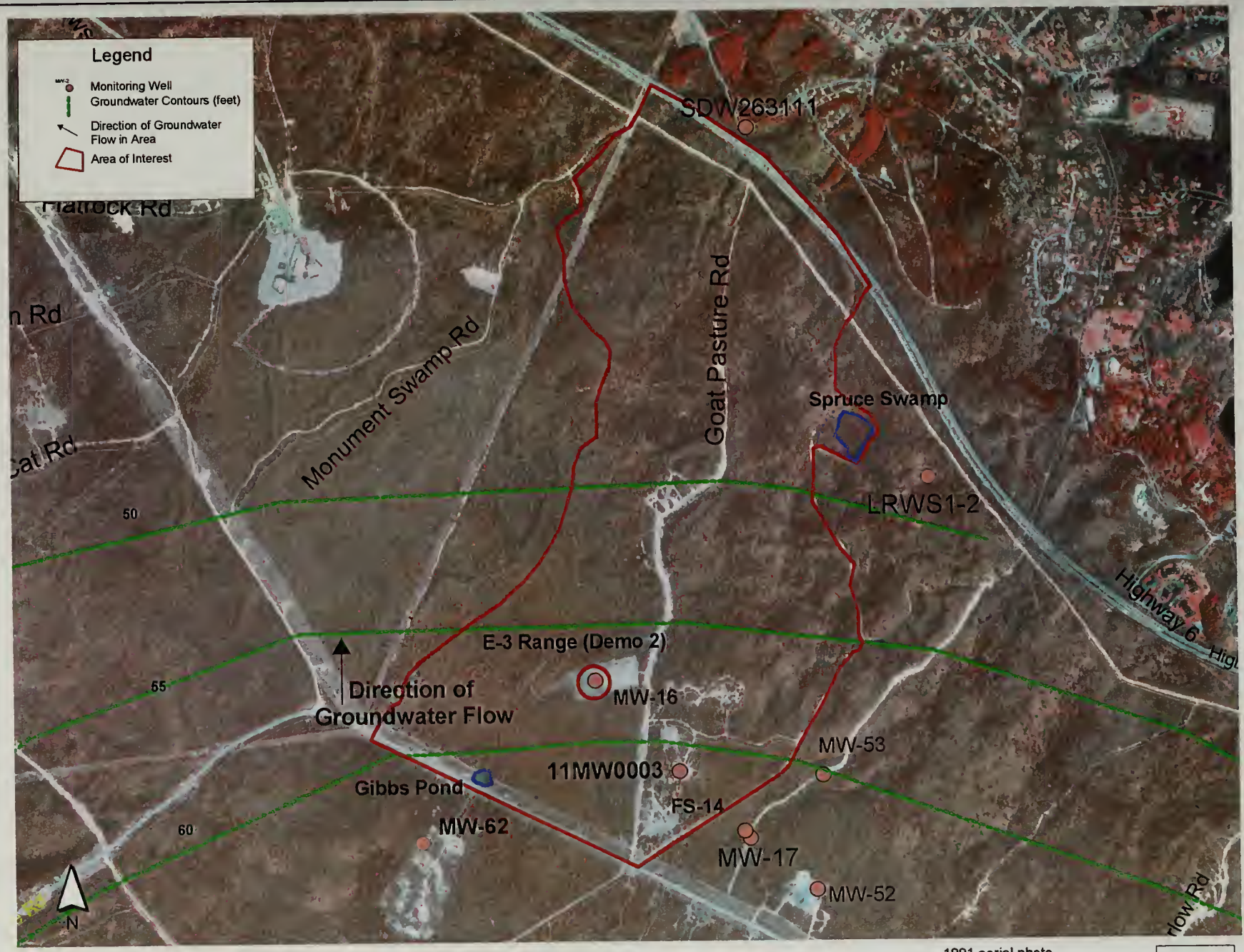


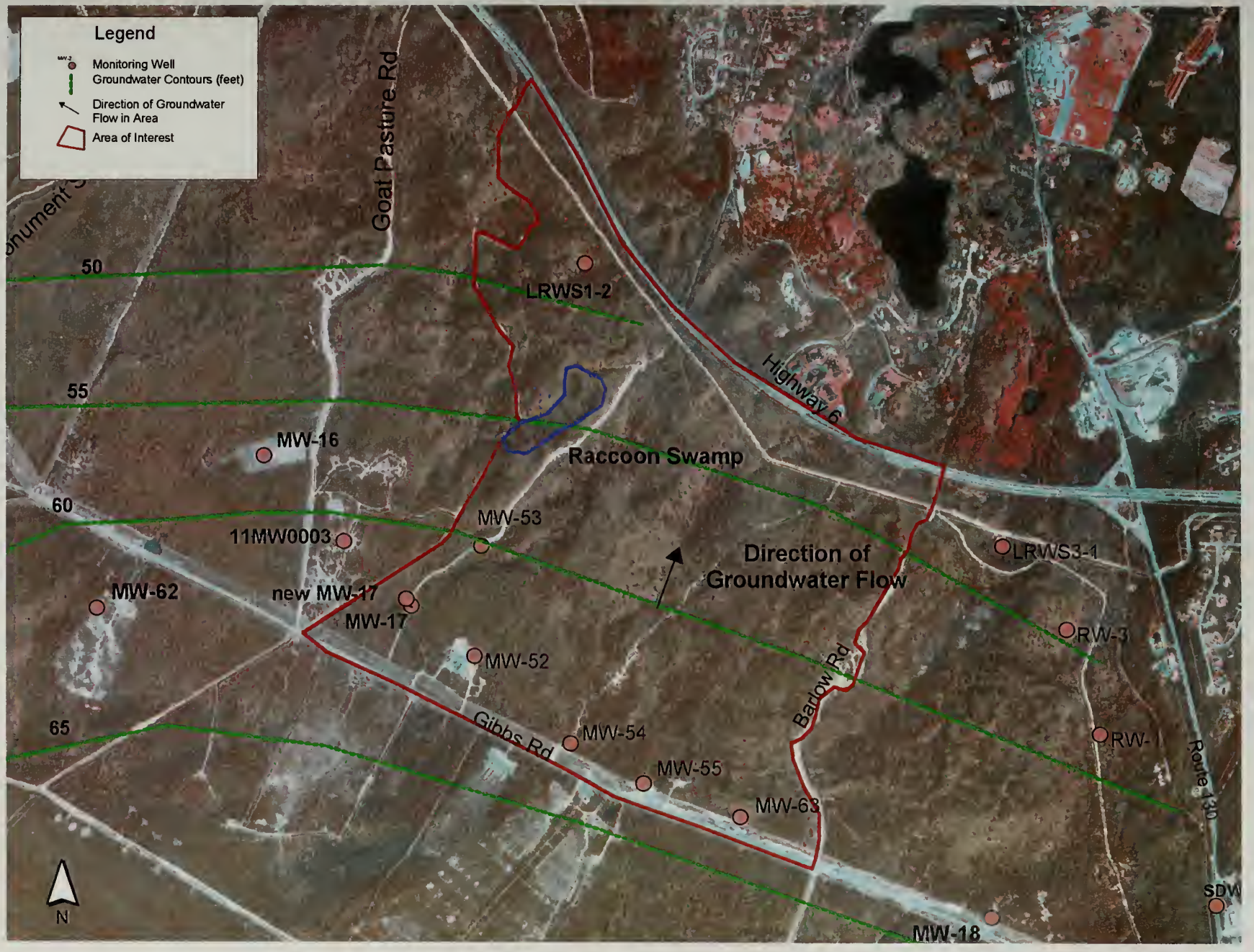
Figure 2-9

Training Area C-13



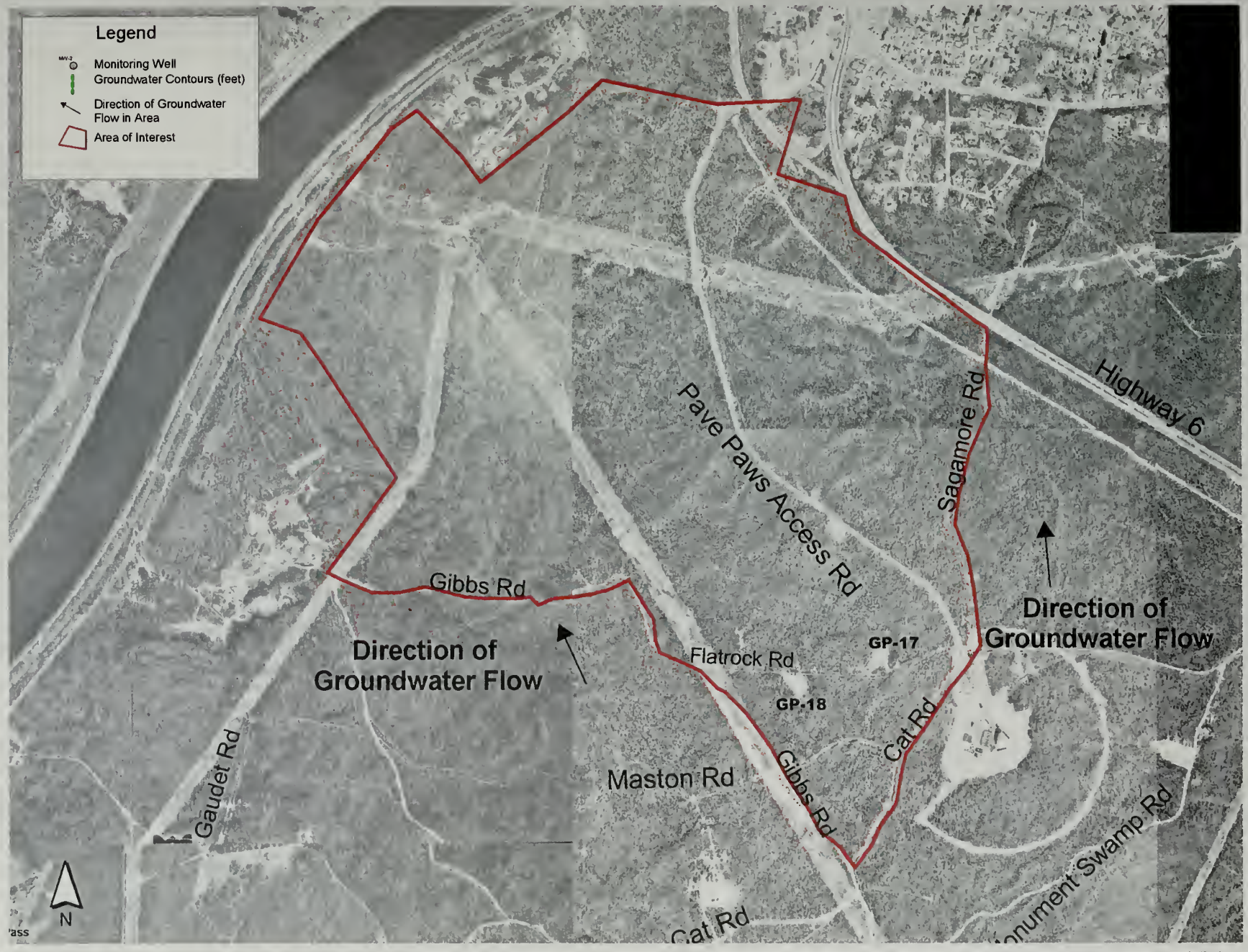
Training Area C-14

Figure 2-10



Training Area C-15

Figure 2-11



Training Area B-12

Figure 2-12

Response to EPA Comments dated 2/9/00 and 3/2/00,
and MADEP Comments dated 2/15/00 on the Draft Training Areas Workplan (7/23/99)

EPA General Comments:

1. (2/9/00) In Sections 3.1.2 and 3.2.3, NGB proposes to use estimated exposure criteria to select a method of 2-chlorobenzalmalononitrile (CS), pyrotechnics, and dye analysis. The purpose of this investigation is to determine the nature and extent of contamination. Consideration of exposure criteria or risk will be conducted once the investigation results have been determined to be appropriate and complete. NGB should present a summary of the methods that are considered feasible for CS and dye analysis. The information for each method should include a list of all analytes and detection limits.

   (2/29/00) The proposed consideration of potential exposure criteria was intended to address the role of Data Quality Objectives (DQOs) in method development, in accordance with EPA guidance. The EPA's DQO guidance indicates that the end use of the data must be considered in designing the plan to determine nature and extent of contamination. Using an example from the DQO guidance, one would need to know that the level of concern for TCE is 5 ppb in groundwater before selecting an analytical method with a detection limit less than or equal to this value.

   The end use of the data for the IAGS is for an evaluation of contaminant impact on the aquifer. For many compounds this evaluation simply consists of comparing measured concentrations in groundwater with EPA's drinking water criteria. For example, if an RDX concentration measured in groundwater exceeds the lifetime Health Advisory of 2 ppb, there is an adverse impact that needs to be addressed. Where contaminants are present in soil, a <u>potential</u> impact is determined by estimating the transport of the contaminant to groundwater. The method of estimation can vary from site specific modeling, as is currently being planned for the explosive contaminants of concern, to use of generic cleanup standards (e.g., MCP Method 1 standards) that are based on simplifying assumptions for contaminant transport. Regardless of how the transport to groundwater is estimated, the resulting groundwater concentrations must be compared to drinking water criteria.

   The fundamental problem in evaluating the potential for groundwater impacts for CS and the dyes is that there are no drinking water standards for these compounds. If the compounds are measured in groundwater (or in soil, with transport to groundwater estimated) there are no criteria to determine whether the impacts warrant remedial action. The situation would be analogous to some of the current target analytes, such as the herbicide MCPP, that have been measured in groundwater but have no applicable drinking water standards. The agencies have not identified MCPP as a contaminant of concern for drinking water.

The Guard submitted an extensive evaluation of dye ingredients and mobility to groundwater in its 12/9/99 submittal to the agencies. This evaluation concluded that the dyes lack the necessary solubility and mobility to be transported in any form other than as particulate-bound matter. There is no mechanism for transport of particulate-bound material to groundwater. The evaluation further concluded that there are strong photolytic and anaerobic pathways for removal of surface-deposited dyes. EPA's response provided in their 2/14/00 letter stated "information on transport and fate in the environment is non-existent". The Guard disagrees that these data are "non-existent", and asks EPA to review the information in the 12/9/99 submittal.

All of the listed dyes absorb strongly onto particulate matter and are considered immobile in the environment. Their high log Koc values demonstrate that once released, they will bind to organic material or particulate and not be accessible for transport to groundwater. Reported studies indicate that these dyes will rapidly photodegrade when exposed to natural light. Given the means of dispersion from smoke munitions at the site, surface deposition, exposure to natural light and photodegradation would be the principal fate for these dyes. Any dyes deposited on surface water bodies would bind to particulate and then be subject to anaerobic degradation.

The Guard's 11/29/99 submittal provided additional information for a number of potential analytes, including CS. The Guard noted that CS has a short half-life and recommended against its analysis, since it is unlikely to persist in the environment since its last use. The DEP notes in their comments (see below) that CS has a low solubility in water and hydolyzes rapidly, with a half-life of 15 minutes. Studies of its persistence in soil at Eglin Air Force Base estimated that its half-life in soil at that facility was 3.9 days. While the soil characteristics at MMR are likely different and might result in a somewhat longer or shorter half-life, any exposure to rain would result it its hydrolysis.

The Guard proposes to withdraw its recommendation in the draft Training Areas Workplan (7/23/99) to develop methods for analysis of CS and dyes in soil. Recent submittals as indicated above provided data that indicate these compounds are not persistent or mobile in the environment. Moreover, there are no drinking water criteria for these compounds that would allow an evaluation of potential impacts on the aquifer. The Guard request the opportunity to discuss this issue with EPA during the comment resolution meeting.

(3/2/00) EPA disagrees. All analytes currently being investigated are contaminants of concern in the groundwater study. This is appropriate in light of the early stages of the

investigation, the novel nature of many of the issues the study is addressing, the imperatives of sound science, the importance of the underlying aquifer, and the fact that the data has regularly revealed environmental problems in the Impact Area and Training Ranges that NGB asserted did not exist.

For example, MCPP is one of several compounds (including explosives) for which NGB made the argument that due to chemical properties, the compound would never travel through the soil and appear at detectable concentrations in the aquifer. To date, there have been four validated detections of MCPP in groundwater from monitoring wells on the northern portion of the base, with concentrations ranging from 230 ug/l to 1,300 ug/l. While EPA has not published a Health Advisory for this contaminant, a risk-based concentration based on known chemical properties of the contaminant (or like contaminants) indicates that MCPP poses a risk in drinking water where it exceeds 36 ug/l.

In effect, all detected contaminants are viewed by EPA as Contaminants of Concern (COCs), and if any are taken off this list, it will be done after a thorough risk screening process after a more thorough understanding of the issues has been reached. This methodology has been carried out numerous times as part of the Installation Restoration Program cleanup on the southern portion of MMR.

The requests contained in EPA's 9 February 2000 and 14 February 2000 correspondence stand. NGB is hereby notified that failure to comply with the requirements as laid out in above-referenced EPA correspondence will be a violation of EPA Administrative Order SDWA 1-97-1019.

(3/14/00) NGB agrees to begin development of suitable soil and groundwater analytical methods for detecting the following chemical compounds associated with chemical warfare simulant and pyrotechnic smoke use:

- *chlorobenzaldehyde [a degradation product of 2-chlorobenzalmalonitrile (CS)]*
- *benzanthrone (yellow dye)*
- *dibenzo(a,h)pyrene-7,14-dione (vat yellow 4 dye)*
- *1-methylaminoanthraquinone (red dispersal dye)*
- *1-4-diamino-2,3-dihydranthraquinone (violet dye)*
- *1-4-bis(p-toluidino)anthraquinone (green dye)*

Summaries of the analytical methods that are considered feasible for these analytes will

be provided to the agencies as method development is completed. Two pyrotechnic smoke constituents of interest, hexachloroethane (HCE) and barium nitrate, are analytes that can be detected under current IAGS methods.

2. (2/9/00) The method specifications (e.g., detection limit, etc.) for the analyses approved by EPA for CS, pyrotechnics, and dye analysis should be presented as an addendum to the Quality Assurance Project Plan, upon EPA approval.

   (2/29/00) See the response to EPA General Comment No. 1.

   (3/14/00) Each of the methodologies selected for the above compounds will be submitted to EPA and MADEP for approval prior to inclusion in the IAGS Quality Assurance/ Quality Control (QA/QC) Plan. Method detection limits and sample management requirements (sample collection and handling) will be documented in the QA/QC Plan.

EPA Specific Comments:

1. (2/9/00) Page 1, Introduction – The first paragraph states this work plan has been developed to "address the nature and extent of contamination associated with the use of chemical warfare stimulants (riot control agents), pyrotechnic smoke devices (smokes), and herbicide use . . .". According to Section 3, Subpart D of EPA's Modification of Scope of Work letter dated July 17, 1998, the above parameters were called out in addition to the complete list of Phase I analytes. This work plan should include sampling for other materials which have been found or disposed in the training areas, including fuel oils (see Archive Search Report, Morin interview), solvents used to clean weapons (see Archive Search Report, Appendix I-8, Studley interview), explosives and propellants.

   (2/29/00) The draft Training Areas Workplan was intended to address specific types of activities in the Training Areas (i.e., use of smokes and tear gas), with other activities addressed under the Phase II (b) Workplan and Supplement. EPA indicates above and in its comments on the latter workplan that the two workplans should overlap with regard to the activities to be addressed. The Guard will revise both documents as appropriate.

   The referenced text will be modified and subsections will be added to Sections 2 and 3 to address fuel oil disposal, weapons cleaning, explosives use, and propellants use. IAGS groundwater samples have been tested for the full suite of Phase I analytical parameters allowing for the assessment of contaminants related to fuel oils, solvents, and PEP compounds. Given the limited information available on the actual locations where these materials may have been released, the Guard will focus on groundwater monitoring for

evaluating the impacts of activities described above.

(3/14/00) Soil samples collected under this workplan will also be analyzed for the full suite of Phase I parameters in addition to the compound(s) of interest (for which methods are to be developed) to account for the possibility of ancillary contaminants such as chlorinated solvents, petroleum products, and CAIS kits resulting from other, possibly unrelated training activities. Sampling locations will be selected following field reconnaissance conducted with EPA and MADEP. Selected locations will be representative of the full range of potential releases associated with training activities. Locations will be documented in a draft Field Sampling Plan for agency approval.

2. (2/9/00) Page 1, Paragraph 1 – In addition, EPA assumes that the category of "pyrotechnic smokes" will include all forms of pyrotechnics, including flares, fog oils, smoke grenades and tracers, and that the category of "chemical warfare simulants" will include chemical agent identification sets ("CAIS kits"), the chemical gas kits described by Mr. Cullity and other interviewees, as well as the gas canisters used inside bunkers.

   (2/29/00) Pyrotechnic smokes include all ordnance specifically designed to generate smoke and known or suspected of having been used at Camp Edwards. It is unclear that the vials Mr. Cullity discovered near Spruce Swamp 9 or 10 years ago were components of a CAIS kit.

3. (2/9/00) Page 1, Paragraph 3 – The NGB is required under the July 1998 modification to the SOW to study all training areas, regardless of whether they were exclusively used prior to 1984. Please revise the sampling plan to ensure that no areas are excluded on the ground that they were used only before 1984.

   (2/29/00) No areas were excluded on the grounds that they were used only before 1984. The referenced text indicates that such areas would be eligible for investigation under the IRP, but does not state that they were excluded from this workplan.

4. (2/9/00) Page 3, Paragraph 2 – In the ACOE ASR, Appendix F-79, Page 53 quotes a 25 September 1941 memorandum which states that in regard to Camp Edwards and Fort Devens, "Adequate gas chamber facilities are available at both stations and all personnel have been exposed to tear gas and chlorine." This same reference also states " . . . well planned training areas have been located at sufficient distance from congested camp areas to allow exercises with live chemical agents." Please review the ASR, and any additional information which can be obtained, and revise this paragraph. See also Appendices F-17 and H-1. Generally, chemical defense training has been a part of the military's training

since 1917. Training requirements during WWI required all U.S. troops to be given chemical training before deployment to Europe.

(2/29/00) The ASR will be reviewed again with the specific focus on gathering information on the historical use of live chemical agents at Camp Edwards. No references to live chemical agent use at Camp Edwards (either documents or interviews) have been discovered to date. The excerpt EPA cites does not state that live chemical agents were used in troop training, referring only to the adequacy of camp facilities for such training activities.

(3/14/00) Field reconnaissance will be conducted as described in the response to EPA Specific Comment No. 1. Any visible evidence of chemical agent release will be considered in preparing the Field Sampling Plan.

5. (2/9/00) Page 3, Section 2.1.1 – Revise the first sentence based on information contained in the Addendum to the ASR (i.e. "oily liquids" were sprayed from the air onto leaves in the 1970's to simulate a chemical attack, among other accounts).

(2/29/00) Evidence of spent tear gas grenades within the training areas suggests that open-air chemical warfare simulant training may have occurred on occasion at Camp Edwards. The sentence will be modified to reflect this.

(3/14/00) Information from the interviews of Cullity and Frederick will be incorporated as appropriate.

6. (2/9/00) Page 3, Section 2.1.1 – In the sixth line of the first paragraph, please change "where" to "were".

(2/29/00) The change will be made as requested.

7. (2/9/00) Page 4, Paragraph 6 (Training Area A-4) – In the fifth line, please change "current" to "currently".

(2/29/00) The change will be made as requested.

8. (2/9/00) Page 5, Section 2.2 -- In evaluating pyrotechnics/smoke use, NGB should consider the full range of pyrotechnics used (see for example ASR Report F-64), and search MIDAS and other available sources for a full range of the chemical constituents of the pyrotechnics used and their combustion and degradation byproducts. For example,

based on information provided to EPA by the NGB in 1997 on pyrotechnics used at MMR in the few years prior to 1997, the following are constituents of pyrotechnics used in the past:

-Hexachloroethane (HCE): HCE is contained in 104 Smoke HC An-M8 hand grenades (last used at MMR in 1996), and smoke pots 301b ABC-M5 (also used at MMR). HCE combines with zinc oxide, another ingredient in An-M8 smoke grenades, to produce zinc chloride and aluminum.
-Yellow dye (benzanthrone): used in M-18 yellow and green smoke grenades
-Vat yellow 4 dye (dibenzo (a, h) pyrene-7,14-dione): used in M-18 yellow grenades, M-18 green grenades, M715 green markers, and M0716 green markers, all of which were used at MMR.
- 1-methylaminoanthraquinone (red dispersal dye): used in M-713 red smoke markers at MMR.
- 1-4-diamino-2, 3-dihydranthraquinone (a violet dye): used in M-18 grenades.
- 1,4-bis (p-toluidino) anthraquinone (a green dye): used in M-18 green smoke grenades.
- barium nitrate: constituent of CTG 40mm Red Smoke M713; CTG 81mm Illum 301/w fuze time M84; smoke grenades; signal illuminations; simulator air burst M74A1; and simulator ground burst M115A2.

Of the above, only Hexachloroethane and barium nitrate can be considered a true current analyte (OC21B and IM40MB, respectively). EPA requests, by way of the above comment, and comments which will be submitted separately on the Draft PEP Report, that method development proceed for the above remaining compounds.

(2/29/00) A search of chemical constituents and their combustion and degradation byproducts was performed for the Draft PEP Analytical Report (11/30/98). See the response to EPA General Comment No. 1 regarding method development.

(3/14/00) See the revised response to EPA General Comment No. 1. Methods will be developed for the five dyes referenced above.

9. (2/9/00) Page 9, Section 3.1.2 – The Guard's investigation should include, to no less an extent, the former Chemical Warfare Training area located along Pew Road, just north of the intersection with Estey Road. An effort should be made to verify that Pew Road is the location of the gas chambers used during the 1940's (See ASR Report, Appendix F-17); if these are not, then an attempt should be made to delineate this area.

(2/29/00) See the response to EPA General Comment No. 1 regarding method

development. The Guard proposes to withdraw its recommendation for an investigation of CS in soil.

(3/14/00) See the revised response to EPA General Comment No. 1. The Guard will develop an analytical method for chlorobenzaldehyde, a breakdown product of CS. The Pew Road training locations will be included in the soil sampling effort. The Guard will attempt to verify the location used for gas training during the 1940s.

10. (2/9/00) Page 9, Section 3.1.3 – Soil samples collected from the Chemical Warfare simulant areas (both areas, as noted above), should be analyzed for all Phase I parameters, in addition to CS. Given the evidence that chemical agents may have been used as well at B-8, A-5, Land Nav II, C-15, BA-4, A-4, C-16 and GP-12 (ASR and Addendum to ASR), sampling should also be conducted at some of these areas. The NGB should propose a sampling program for chemical agent contamination for these areas. It may be appropriate to sample at locations where gas grenades have been found (e.g. at C-16), or the locations in C-14 and near the Pave Paws site where Mr. Cullity observed evidence of gas use or disposal; or at the southern LZ along Barlow Road where Mr. Zanis found possible CW kits.

(2/29/00) See the response to EPA General Comment No. 1 regarding method development. The Guard proposes to withdraw its recommendation for an investigation of CS in soil. CS grenades contain CS, black powder, and a mixture of iron oxide, zirconium, and titanium. Testing for all the Phase I parameters is not warranted.

(3/14/00) See the revised response to EPA General Comment No. 1. The Guard will develop an analytical method for chlorobenzaldehyde, a breakdown product of CS. Continued records research on historical tear gas training activities, including reviewing the ASR and its Addendum, will focus on historical training exercises performed in Training Areas B-8, A-5, Land Nav II, C-15, BA-4, A-4, and GP-12. Based on the findings, NGB will propose collecting representative soil samples from areas where evidence of this type of training was most active. Field reconnaissance of these areas will be conducted as described in the response to EPA Specific Comment No. 1.

(2/9/00) In addition, given that burial or landfilling of chemical warfare material was a standard method of disposal until the 1960's, the NGB should propose some method to search for and sample potential disposal sites.

(2/29/00) To date, no historical record of live chemical agent use has been discovered for Camp Edwards. Records indicate that only chemical agent simulants such as CS have

been used for this type of training exercise. Testing for live chemical agent disposal is not warranted at this time.

(3/14/00) Field reconnaissance of the tear gas training areas will include evaluation of any visible evidence of chemical agent disposal.

11. (2/9/00) Page 13, Section 3.2.4 – It is insufficient to test a single representative area for potential residues of smokes or other pyrotechnics, given the broad use of pyrotechnics on the training ranges and the wide dispersal of pyrotechnics debris on the ranges. EPA suggests testing at five or six areas to get a broad sense of the pyrotechnic issue. This could include IBC range, B-8, C-16, A1, and BA4. The KD Range should also be considered, since a high number of TICs has been documented during previous sampling.

(2/29/00) See the response to EPA General Comment No. 1 regarding method development. The Guard proposes to withdraw its recommendation for an investigation of dye compounds in soil.

(3/14/00) NGB proposes to expand the search for evidence on pyrotechnic smokes to include areas outside of the IBC Range. Ten of the proposed 20 IBC Range soil grids will be moved from the IBC Range to other locations as determined by the reconnaissance survey results. These ten new locations will be selected with input from EPA and MADEP after the laboratory results for the IBC Range have been reviewed.

12. (2/9/00) Page 14, Section 3.3 – Soil samples should be collected from along the two (out of three total) power line right-of-ways in the western portion of Training Area B-12 to verify the conclusion that appreciable concentrations of herbicides do not exist in this portion of the training area. In addition, NGB should revisit whether sufficient sampling conducted in earlier rounds at Donnelly Pond and Deep Bottom Pond (defoliation drum staging areas), now that additional information has been gathered in the ASR and Addendum.

(2/29/00) Regarding the testing of soil along two of the three power line corridors, no evidence has been discovered that the Guard has used herbicides along the power line corridors. The Guard will, however, revisit the research report (Deubert, 1985) to best determine the location of the herbicide experiment and collect representative surface soil samples to verify the report conclusion that herbicide residuals should no longer be present there.

(3/14/00) NGB will obtain samples from two soil grids established along two of the three

power line easements located in the western portion of Training Area B-12 to assess the presence of herbicide residuals. The samples will be analyzed for the full suite of Phase I parameters.

MADEP General Comments:

1. Please clarify whether the tearing agent ("CS") used in a training area "gas chamber" is as concentrated as the CS found in a tear gas canister. This fact should be verified to confirm whether the chamber floor is "worst case".

   (2/29/00) See the response to EPA General Comment No. 1 regarding method development. The Guard proposes to withdraw its recommendation for an investigation of CS in soil, considering its low mobility and persistence, and lack of drinking water standards.

   (3/14/00) See the revised response to EPA General Comment No. 1. This issue is now moot because samples will also be collected in areas where canisters were used.

2. Please verify whether CS and smoke are subject to photodegradation. The Department understands that CS and smokes are aerosols/solids when dispersed, and that they are of low solubility in water, where they hydrolyze rapidly (their half-life in water with a pH of 7.00 is 15 minutes).

   (2/29/00) Studies of CS persistence in soil at Eglin Air Force Base estimated that its ½ life in soil at that facility was 3.9 days. While the soil characteristics at MMR are likely different and might result in a somewhat longer or shorter ½ life, any exposure to rain would result it its hydrolysis. Given the rapid hydrolysis of CS to chlorobenzaldehyde in the presence of water (as indicated by the short half-life referenced by MADEP), CS would not be expected to have persisted at MMR unless protected in some manner from the elements, in which case it would not be mobile to groundwater.

   Photodegradation of dyes was documented in the Guard's 12/9/99 response to comments on the draft PEP Analytical Report. All of the smoke dyes included in photodegradation experiments demonstrated significant losses with exposure to natural sunlight. With 50 hours exposure, losses of at least 40-50% were noted. Products of photolysis which have been detected and identified are smaller molecules with shorter half-lives than the parent dyes.

3. Please identify a background site for sampling and analysis for CS and smokes to support

this study.

(2/29/00) See the response to EPA General Comment No. 1 regarding method development. The Guard proposes to withdraw its recommendations for investigations of CS and dyes in soil, considering the low mobility and persistence of these compounds, and lack of drinking water standards.

(3/14/00) See the revised response to EPA General Comment No. 1. A background area will be identified during field reconnaissance with the agencies, and included in the FSP.